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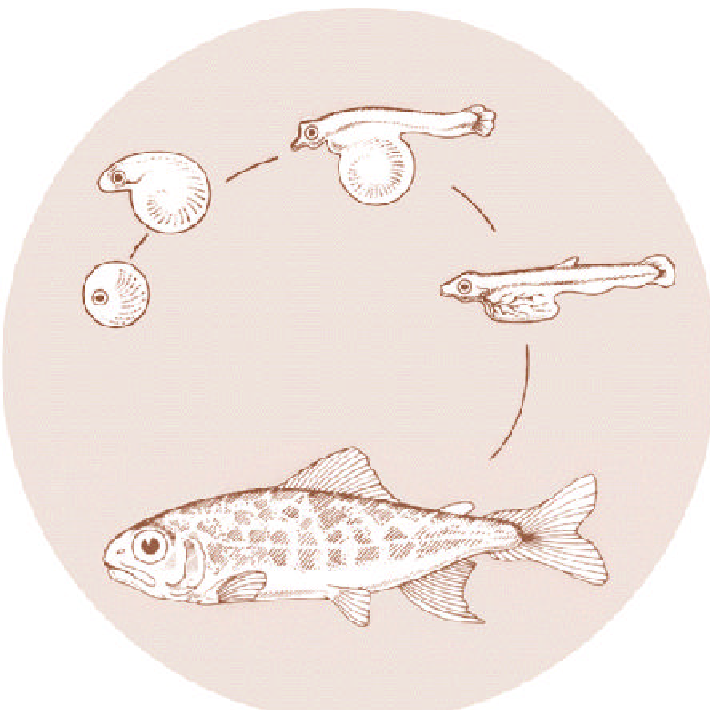
CONCEPTUAL PLANS FOR QUALITATIVELY & QUANTITATIVELY IMPROVING ARTIFICIAL PROPAGATION OF ANADROMOUS SALMONIDS SALMONIDS IN THE COLUMBIA RIVER BASIN



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CONCEPTUAL PLANS FOR QUALITATIVELY AND QUANTITATIVELY IMPROVING ARTIFICIAL PROPAGATION OF ANADROMOUS SALMONIDS IN THE COLUMBIA RIVER BASIN

Prepared By

Gerald R. Bouck

Action Item 34.23
of the
Columbia River Basin
Fish and Wildlife Program (1984)

Prepared For

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Executive Summary

Long range planning is required to identify the resources and actions needed to produce additional hatchery fish and increase hatchery effectiveness. Given typical lead times, one can expect about 10-15 years to lapse between the time BPA requests authority for capital projects and the time the first adult fish return via that project. In this process, it is critical to establish "proximate," numerical fish production goals for planning purposes. The species of fish and the location of their production can be generalized for these purposes, albeit, these data must be refined into discrete, specific subbasin plans. For purpose of this report, generalized scenarios are used to identify possible solutions and their costs.

This report is in response to Action Item 34-23 of the 1986 Columbia River Basin Fish and Wildlife Program: "Evaluate ongoing work under [Section] 704(h) and submit a plan to the Council for future efforts--[in improving hatchery effectiveness]. Consultations and recent literature were evaluated along with ongoing BPA-funded projects. As a result, a plan was developed for quantitatively and qualitatively increasing the production of anadromous salmonids using existing technology and existing hatcheries. This plan is based on a numerical goal whose rationale is as follows:

For planning purposes a numerical goal for total salmon and steelhead production in the Columbia River Basin was set arbitrarily at 10 million adults per year. Given that the full propagation potential for wild/natural salmon/steelhead is about 3.5 million adults, and given that the current hatchery production of salmon/steelhead is about 2.5 million adults per year, therefore; hatcheries might need to produce as much as 4 million more adults per year (depending on the benefits of improved mainstem passage, and habitat restoration).

An interim goal for hatcheries is needed to facilitate and guide financial and bioengineering planning. Thus for planning purposes, this report established the following goal: explore the ways and costs of increasing smolt production at existing hatchery facilities to produce 2 million additional adult fish/year. This goal, albeit for planning purposes, appears to be realistic and attainable through four general approaches which have inherently different costs. These approaches are as follows:

1. Purchase of 200 million smolts per year from commercial sources to produce 2 million adults (assuming 1 percent survival) was estimated to cost $66.6 million per year. This is replete with biological and political problems, and is potentially the most expensive alternative. Presently there is no salmonid rearing capacity existing in commercial aquaculture for 200 million smolts per year.

2. Construct additional, traditional hatchery facilities to provide 2 million more adults per year would cost at least $548 million, assuming that the additional production would require 13.3 million pounds of smolts at $41.11 per pound of propagation capacity. However, hatchery construction costs in recent years have exceeded $70 per pound of propagation capacity and if this trend prevails, the resulting capital cost would be nearly $1 billion. Require operation and maintenance (O&M) in this scenario would be about $32 million when full production is reached.

3. Modify, expand, and improve about 50 existing hatchery facilities to provide at least 1.5 million more adult salmon/steelhead per year at an estimated capital cost of about $100 million. In this scenario, renovations would begin in year 5 and proceed at 20 percent per year over 5 years. O&M would begin in year 6, when production additions would cost $5 million per year and increase annually over 5 years to an estimated $25 million per year. These proposes changes would allow full utilization of existing water supplies, provide supplemental oxygen for higher rearing densities in existing facilities, and minimize facility-related health problems. Total cost of this approach is estimated to be $175 million over a lo-year period including capital costs, expense, and O&M.

4. Increase Smolt quality to achieve higher survival could produce at least 500,000 more adults per year, albeit, the potential benefits could be much greater. The intensive production technology implemented could require heavy use of antibiotics at surface water facilities to minimize disease outbreaks requiring intensive efforts in certifying new drugs. Estimated costs are $1 million per year for increased fish health monitoring.

Investments in concrete and steel must be balanced with equally important investments in the hatchery staffs who rear the fish. These critically needed professionals must have both the motivation and the best technological tools to improve quality and survival. Primary needs include better technology transfer, peer-based performance evaluations, professional certification/recognition, incentive awards, and basin-wide evaluation of Smolt survival. Supportive objectives include the registration of drugs for use in hatcheries, better sanitation, and increased fish health monitoring.

Supportive research and demonstration projects are critical to further expand hatchery effectiveness. These projects address: improved strategies and practices in fish culture; better ways and means to protect the health and genetics of hatchery and wild fish; improved smoltification and early marine survival; and resolution of problems at existing hatcheries with records of poor success.

Preliminary cost estimates are included for each objective in the Plan, and these total $231.5 million over a lo-year period. This time period is needed to accommodate a minimum waiting period of 2 years for the budgetary process in noncapital projects and at least 3 years for capital projects. Design, procurement, and construction phases probably would consume another 3 years. The first brood of smolts could be release in another 2 years, and adults might return in another 2 years, or at least 10 years after the proposed projects have been approved. Thus, the goal of 2 million more adult salmon/steelhead might be achieved in 12 to 15 years or 2,000 A.D., assuming no additional delays.

I. Introduction

In 1984, the Northwest Power Planning Council (Council) amended its Fish and Wildlife Program (Program) to include an Action Plan (Section 1500), to give focus and priority directions to varous aspects of the Program. Regarding "Improved Hatchery Effectiveness," Bonneville Power Administration (BPA) was requested to evaluate ongoing work under 704(h) and submit a workplan to cover future efforts. This report provides concepts for increasing hatchery effectiveness. Additionally, it proposes numerical goals for increased fish production, identifies ways to accomplish them and lists supportive objectives, project schedules, and preliminary budgeting information.

Program Area Goal

Preliminary data from subbasin planning indicates a large additional need for artificially reared salmon and steelhead in the Columbia River Basin. The total need depends upon many factors and this information will be developed and refined as subbasin plans are completed. Recently constructed fish hatcheries are coming on line, and other hatcheries are expected to be prescribed. This workplan is directed at increasing fish propagation at existing facilities, as described in Program Section 700. In doing this, four approaches were considered and evaluated: (1) purchasing smolts from commercial sources; (2) building additional but typical hatcheries; (3) modifying existing hatcheries to increase their production with supplemental oxygen; and (4) increasing smolt quality to increase survival, via various supportive actions.

Numerical production goals for salmon and steelhead have not been established in the Fish and Wildlife Program narration[1/]. Interim numerical goals are needed for planning purposes and are proposed in this document. These interim goals bind no one but give perspective and allow planning and evaluation processes to proceed. Specific production potentials for each subbasin will be established in the subbasin plans.

The specific goal proposed in this plan is to increase the amount of annual, artificial propagation at existing facilities, so as to provide 2 million additional adult salmon/steelhead per year to the Columbia River Basin possibly by the year 2000. Such a discrete goal allows the transformation of programmatic direction and former acrimony into specific project plans and schedules, but more importantly, into fish. Certain aspects of these plans are unresolved, such as areas and stocks of emphasis, but it is none-the-less critical to establish generalized numerical goals against which one can develop strategic plans, evaluate alternative approaches, estimate budgetary needs, and schedule the ensuing tasks. Such plans should not be considered immutable, but subject to dynamic revisions.

1/ The Northwest Power Planning Council (Council) recently announced its opinion that the Columbia River Basin hydrosystem adversely impacts the salmon and steelhead runs by 5 to 11 million adults per year. These figures indicate that the Council is requesting total adult population ranging from at least 7.5 to perhaps 13.5 million (average = 10.5 million).

Most ofthe objectives in this report rely on existing knowledge and proven technology. In many cases, the plan only seeks to modifying facilities or practices to achieve "state-of-the-art" conditions. Research will be needed in a few cases, when a problem blocks or reduces opportunities for full success. However, the primary goal of this plan is to enhance fish propagation at existing facilities. Thus, when contemplating actions pertaining to this plan, one should constantly ask, "How does this action relate to the goal of providing 2 million more adult salmon and steelhead per year?"

Given these considerations, the goal of 704(h) could be translated into: "improve the quality and quantity of propagation at existing facilities to achieve 2 million more adult salmon/steelehead per year by the year 2000."

Role of EPA

The role assigned to BPA is to implement the broad goals of the Council's Program consistent with relevant public laws. This requires BPA to define and evaluate Program needs against ways and means to accomplish them. A primary strategic choice is to obtain the best value for the Basin and assure wise expenditures of ratepayer funds. To do this, EPA works closely with its publics (fishery agencies, Tribes, utilities, universities, etc.) to define specific needs and projects. To refine the goals, BPA challenges the validity of widely supported assumptions, popular beliefs, and cherished traditions. Therefore, EPA's role in 704(h) is to catalyze and facilitate the identification of needs, evaluate alternatives, and administer the funding and oversight of BPA funded projects.

Implementation Process

This plan identifies objectives and certain approaches but does not describe the details of specific projects or tasks as such. A Technical Guidance Committee is expected to develop detailed project descriptions, schedules, and related coordination. Such a Guidance Committee could consist of the managers of hatchery programs in each agency, as well as representation from the Tribes, Public Utilities, U.S. Army Corps of Engineers (COE), Northwest Power Planning Council, and other entities.

Detailed planning could be accomplished while awaiting the availability of funds: noncapital projects usually must wait about 2 years, and capital projects generally wait at least 3 years before funding will be available.

II. Need for Artificial Propagation

Artificial production of anadromous salmonids is a firmly established practice in the Columbia River Basin dating back to 1876 (Wahle and Smith, 1979). Development of early facilities was motivated in part by the desire to mitigate fish lost to fishing and poor land management practices, albeit the current need includes mitigation for the construction and operation of dams provide the fish for harvest. Many of the early hatcheries were short-lived in function but long-lived in terms of their bad reputations. Now over a century later, hatcheries are several generations improved over their precursors and theoretically, if not currently, capable of producing fish equal to wild fish. Modern hatcheries also have benefit/cost ratios which justify further investment. For example, Wahle et al. (1974) and Wahle et al. (1978) reported benefit/cost ratios which averaged 7.1/l for coho and 4.2/l for fall chinook. This is particularly important in the light of Nickelson's (1986) analysis and conclusion that Oregon's coho Smolt survival from 1960-1981 was density independent, regardless of origin.

The relative merit of hatchery versus wild fish has been considered in various forums. Suffice it to say that both are needed, and heavily selected by Nature. The usual debate is unfortunate and counter-productive. Yost of the issue stems from personal opinion and perceptions rather than a comparison of data. Unfortunately, hatchery fish tend to be categorically classified as inferior by typical proponents of wild fish. Perhaps this bias was justified in the past and is supported in some instances even today. However, the absence of statistically robust data generally presents numerical comparisons of survival, costs, benefits, and other aspects between wild fish and hatchery fish at or between specific locations. The result fosters a variety of untested speculations which serve more to polarize and entrench, than to clarify and resolve the socio-economic possibilities. The reality is that hatcheries are a necessary and valuable tool upon which a large part of the Pacific salmon fishery is dependent.

Estimate of Basin's Potential for Wild Fish Production

The need for artificially propagated fish can be estimated from the total fish goal of the Columbia River Basin minus the estimated potential for natural production. Therefore, the first step is to establish a numerical, summary goal (albeit interim), estimate and subtract how many fish might be produced via wild or natural propagation; the remainder represents the need for hatchery fish. In this scenario, the concern is for the generalizations which are indicated, and not the specific population levels themselves.

Wild fish production in this scenario, is considered dependent upon and proportional to the quantity and quality of habitat in the Columbia River Basin; this includes all habitat which is or can be made available to anadromous salmonids. Thompson (1976) states that "prior to modern man's influence, some 163,200 square miles of watershed contained habitat ideal for salmon and trout. Today, less than 72,800 square miles remain accessible to anadromous fish and much of that has been transformed to aquatic environment adverse to salmon and steelhead." On this basis, only 45 percent of the watershed remains accessible to anadromous fish. The Northwest Power Planning

Council (1986) estimates that "salmon and steelhead habitat in the entire basin has decreased from 12,935 miles before 1850 to only 8,915 miles of stream presently, a 31 percent loss all due to water development" (Figure 1). However, the effective loss to salmon/steelhead production is probably much greater than 31 percent because serious ecological perturbances have occurred in the remaining accessible streams. Such perturbations include (but are not limited to) siltation of streambeds, water withdrawal, and changes in fish species composition, heat budgets, nutrient budget, water flows, and water quality. Additionally, potential wild salmon/steelhead production is further diminished by the loss of certain gene pools, by Smolt mortality at dams and in reservoirs, as well as by over-harvest of adults in mixed stock fisheries. Therefore, the potential for natural production in today's Columbia River Basin is probably well below 50 percent of the pre-1850 capacity.

Estimates of previous adult salmon/steelhead production in the Columbia River Basin have been compiled. The Pacific Fishery Management Council (1979) estimated that the adult run of Pacific salmon/steelhead trout was 6,241,OOO fish prior to 1850. The Northwest Power Planning Council (1986) estimated that the total adult run of salmon/steelhead ranged from about 10,000,000 to 16,OOO,OOO fish in the predevelopment era; average run size from 1974 through 1983 was estimated to be about 2.5 million adults. These figures are based on computations of harvest using various assumptions. Chapman (cited by Northwest Power Planning Council, 1986) estimated that the predevelopment total adult run was about 8 to 10 million Pacific salmon/steelhead trout. Obviously, the run size is uncertain; no one can precisely define the pre-1850 run sizes; as Beiningen (1976) pointed out, "more definitive information could only be the product of speculation."

The potential fcr wild fish production was estimated for the purposes of this plan, using several assumptions and a simple calculation which does not include the potential additional influence of other factors. For this purpose, variability and other factors are ignored and the following assumptions are used:

(1) The Columbia River Basin's salmonid modal run size was **10** million adults prior to 1850;[2/]

(2) Current available habitat for salmon/steelhead is only **70** percent of the predevelopment level; and

(3) Salmon and steelhead productivity in current available habitat is 50 percent of predevelopment level (due to ecological perturbations).

Therefore:

Estimated current potential for wild and natural propagation of adults = (Predevelopment modal adult run size or 10 million)[1/]

times

(Remaining available habitat or 0.70)

times

(Remaining productivity factor for streams or 0.5) = 3.5 million wild adults.

2/ The total annual run size of hatchery and wild fish would equal 10 million adults. This was selected arbitrarily as an interim goal for planning purposes.

FIGURE 1. Habitat for Anadromous Salmonids in the Columbia River Basin before and after hydroelectric development.

The Pacific Fishery Management Council (1979) estimated that wild/natural salmon production could increase from 1.8 million adults per year over the next 10 to 20 years, provided that further losses in habitat do not occur. On this basis, the previous estimate that wild/natural production could reach 3.5 million wild adults per year seems optimistic and may be unattainable, but this estimate can be used here for planning purposes.

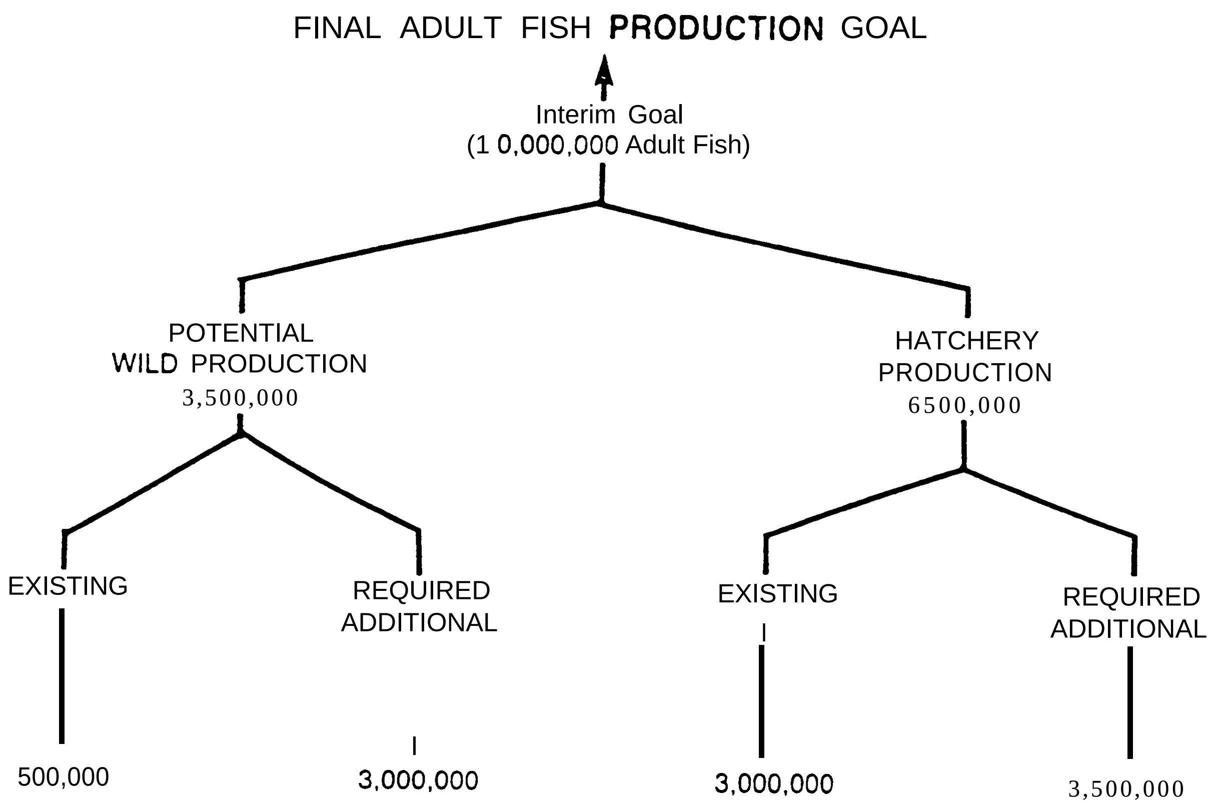
Estimate of Current and Needed Hatchery Capacity:
The total artificial propagation that is needed to replace lost natural propagation capacity can be estimated by subtraction of the above terms (See Figure 2). Again, if a modal value of 10 million adult fish per year is selected as the interim goal, and if the existing habitat could sustain a run of 3.5 million adult fish per year, then total hatchery production must provide a minimum of at least 6.5 million adult salmon/steelhead per year. Estimates of current hatchery production are difficult to quantify, but appear to be in the order of 3 million adults or less per year. If that is the case, then the required additional hatchery production would be 6.5 million minus 3.0 million = 3.5 million adults per year. This is consistent with the Northwest Power Planning Council's (1985b) position that the restoration effort may be large and will require from 5 to 11 million additional adult salmon and steelhead per year. Given these data, it appears that the risk of exceeding the hydrosystem's responsibility is both low in probability and remote over the foreseeable future.

Given the proposed interim goal of increasing adult salmon/steelhead production by 2 million adults per year, one can estimate the additional pounds of production which might be needed. For this purpose, one can generalize smolt survival at 1 percent and release size at 15 fish per pound, respectively. Therefore, additional production capacity would be:

$$\frac{\text{Lb.}}{15\ \text{Smolts}} \times \frac{100\ \text{Smolts}}{\text{Adult}} \times \frac{2{,}000{,}000\ \text{Adults}}{\text{Year}} = \frac{13{,}300{,}000\ \text{Lbs.}}{\text{Year}}$$

Clearly, this amount would change if one alters the numerical values for survival and smolt weight at release. However, 13.3 million pounds of additional production is a reasonable estimate for preliminary planning of capital construction and O&M.

Figure 2. Schematic Representation of the adult salmon and steelhead (combined) goal, estimated sources and numbers of fish.



Estimated Costs of Additional Traditional Artificial Production

Construction cost for facilities to rear2 million additional adult salmon via traditionalhatcheries can beestimated at least two ways: by cost of repl acement and by construction cost for equivalent rearing capacity. If the 1976 artificial production was 2 million adults, then the production of 2 million additional adult fish would require about LOO percent more hatchery capacity. Cleaver (1977) estimated that the replacement costs of existing hatcheries in the Basin was about $180 million in 1976. If replacement costs increased 10 percent per year for the 8 succeeding years, then replacement cost would have grown from $180 million to $390 million. However, this estimate is probably much too low. For example, the Lower Snake Compensation Plan's 12 facilities alone cost about $190 million (personal communication, Ken Higgs, U.S. Fish and Wildlife Service, Boise, ID) or about $95 million per 2 million pounds of rearing capacity.

Capital costs of providing 2 million additional adults can be estimated more accurately from the annual pounds of smolts to be produced. Construction costs vary for traditional hatcheries in the Lower Snake River Compensation Plan because of differences associated with site-specific factors (Table 1) and range from a low of about $20 to a high of $76.58 per pound of designed production capacity,with an average cost of $41.11 per pound of designed production. Senn et al. (1984) provides capital cost estimates for low-cost production facilities which range from $20.50 to $42.20 per pound of rearing capacity. Low capital costs generally require highly favorable conditions with excellent water supplied by gravity, and located in a moderate climate. Higher costs reflect the need for wells, pumping, heating, water treatment, and longer rearing cycles which are typical of facilities for spring chinook and steelhead. Unfortunately, higher capital costs are likely in the future because the best locations have been developed already and the priorities emphasize stocks which have a longer rearing period.

If the average construction cost in Table 1 is used in these calculations, then the estimated cost for new hatchery construction to produce 2 million adult fish would be:

$$\frac{\$41.11}{\text{Lb.}} \times \begin{array}{l}13.3 \text{ million lbs.}\\ \text{of capacity}\end{array} = \$548 \text{ million.}$$

Operating and Maintenance (O&M) costs to rear additional smolts can be estimated two ways, again assuming traditional fish culture techniques. GAIA Northwest (1985)[1/] reported that the O&M costs of the Basin's anadromous fish hatcheries was about $16 million for FY 1984. If the rearing circumstance were similar in the future and little inflation occurred, then the O&M cost of providing 2 million additional adults would be estimated at $16 million per year. However, actual O&M will be higher because of inflation and other factors. Therefore, average O&M costs for 1983 should be adjusted and in this case, the factor of 1.25 was selected arbitrarily and includes an adjustment for inflation. On this basis, the O&M cost for producing 13.3 million pounds of smolts would be at least $16 million per year x 1.25 = $20 million per year.

O&M costs can be estimated more accurately from the rearing cost per pound of smolts produced annually. The 1983 Basin average was $2.42 per pound and these costs vary widely from site to site, depending upon operational circumstances and definitions of O&M (GAIA Northwest, 1985).[3/] Senn et al. (1984)

3/ This report was in response to Section 700 of the Columbia Basin Fish and Wildlife Program.

reported O&M costs of $3.33, $2.49, and $2.05 per pound of capacity, representing extensive, moderate, and no pumping. Therefore, if $2.42 per pound of smolts is used, then estimated total rearing cost would be: $32 million per year for rearing 13.3 million pounds. By comparison, the total revenue loss in 1985 which was associated with the downstream fish passage program was $44 million (memc, June 23, 1986, by Bill Gordon, BPA).

Estimated Costs of Commercially Reared Smolts

Purchase of smolts from commercial sources was considered, but does not appear to be a viable option at this time. There is a question as to whether or not capacity capability exists in private aquaculture for salmon and steelhead production. Supplies of appropriate stocks are unlikely to be available in amounts required for commercial hatcheries. No profit can be assured to a grower, and the lack of assured profit alone seems controlling.

Estimated cost of buying smolts was calculated to be:

$$\frac{\text{13.3 million Smolt lbs.}}{\text{year}} \times \frac{\text{15 smolts}}{\text{Lb.}} \times \frac{\$0.33}{\text{Smolt}} = \$65.8 \text{ million/year.}$$

This price if F.O.B. Springfield, Oregon, and would involve additional costs for transportation to release sites. If the transportation fee was only $0.06 per pound, then one must add about $800,000, yielding an estimated total purchase price per year of $66.6 million.

4/ The cost per Smolt was derived from current prices for coho, steelhead, and spring chinook, at the Oregon Aquafoods Hatchery (Richard Severson, Personal Communication). This level might change given different circumstances.

TABLE 1.

Construction Costs and Estimates of Lower Snake River Compensation Fish Hatcheries1/

Facility (Date)	Projected Pounds of Fish Per Year	Total Construction costs	Cost per Pound of Rearing Capacity	Species
Magic Valley (Nov. 86)	291,500	$ 7,312,OOO	$25.08	Summer Steelhead
Hagerman (Apr. 84)	340,000	6,639,887	19.53	Summer Steelhead
Sawtooth (Nov. 84)	149,000	8,436,371	56.62	Spring Chinook
NcCall (Sept. 82)	61,300	4,694,205	76.58	Summer Chinook
Dworshak 2/ (Nov. 82)	70,000	1,538,743	21.98	Spring Chinook
Clearwater Add. (21%) (Sept. 87) (79%)	441,000	16,607,OOO	37.66	Spring Chinook Summer Steelhead
Lyons Ferry WDG (Nov. 83) & Lyons Ferry WDF (43%) (Nov. 84)	272,000	20,049,737	73.71	Fall Chinook (3%) Spring Chinook (3%) Summer Steelhead Rainbow Trout (17%)
Tucannon Trout (Sov. 84)	41,000	2,396,384	58.45	Resident Rainbow
Irrigon (Oct. 85)	229,600	7,819,044	34.06	Summer Steelhead
Lookingglass (Sov. 82)	69,600	5,207,017	74.81	Spring Chinook
Wallowa (May 85)	50,000	2,127,006	42.54	Summer Steelhead
Totals	2,015,000	$82,827,394		

Average construction cost/lb. of production = $\frac{\$82,827,394}{2,015,000}$ = $41.11

1/ Estimated costs supplied by Ken Higgs, U.S. Fish and Wildlife Service, Boise, Idaho.

2/ Expansion of existing facilities.

III. The Seed for Qualitatively and Quantitively Improved Artificial Propagation

The previous sections predict that a considerable quantitative increase is needed in the production of artificially propagated smolts If the proposed interim goal of 2 million additional adults is adopted, it could require an estimated 13.3 million pounds of additional smolts per year, assuming traditional hatcheries and practices. The costs for this “business as usual” approach provides ample stimulation for seeking less expensive ways to produce the smolts. The use of existing hatcheries, as mandated by the Fish and Wildlife Program, would reduce the need to develop new sites, buy land, acquire water rights, settle disputes, determine environmental impacts, construct new facilities, or hire several new hatchery staffs.

Qualitative improvements in smolts could decrease the total number of smolts needed, as well as greatly reduce the costs for achieving 2 million additional adults. Here the premise is that an increase in smolt quality should translate into higher percentage survival, hence more adults. For example, an increase in overall smolt survival from 1 percent to 2 percent would double the size of the adult run.

Opportunities for qualitative increase in smolt production exist, as judged by Vreeland’s (1985) analysis of fall chinook hatcheries. Of the 24 hatcheries studied, only four facilities produced more than 3 adults per 1,000 smolts released; all others produced less, and some produced almost none. The results indicate that the contribution of adult fall chinook is neither equally distributed among hatcheries, nor necessarily related to passage through dams or reservoirs. Rather, it appears that "quality" factors can have a paramount influence on survival.

Qualitative increases in smolts are not possible in every case, but many opportunities exist for improvement. Many of these portend qualitative improvements in facilities, while in other cases, changes may be needed in husbandry practices. Suffice it to say that these opportunities can be site specific and generic.

The best approach appears to be a combination of qualitative and quantitative improvements of propagation at existing facilities. Quantitative increases in production are feasible, but they are expensive; qualitative improvements decrease most costs, but they are not a sure bet. Therefore, this plan proposes only modest increases in smolt quality which, if achieved, would decrease smolt production goals by 25 percent, i.e., from 13.3 to 10 million pounds.

An example will clarify the potential benefits of qualitatively increased artificial propagation. Given that 13.3 million pounds of smolts were estimated to produce 2 million adults at 1 percent survival, and that O&M would cost $32 million per year. If smolt survival is increased 25 percent, only 10 million pounds of smolts would be needed per year. Obviously, the reduced production would require proportionately less rearing space and feed, thus, capital costs would drop $135 million and O&M costs would decrease by $8 million per year.

Given there would be qualitative improvements, quantitative increases to production are still necessary at existing hatcheries, both by traditional expansion of rearing volume and by moderately increased loading of the total space. These will be described in greater detail in Objective 1. The essence is that some hatcheries have additional water, and these could be expanded to produce an additional 1.7 million pounds of smolts using traditional culture methods. However, many hatcheries could rear more fish in the same space if the available oxygen supply could be maintained at healthy levels.

The cost of providing supplemental oxygen to increase production is vastly cheaper than $548 million for new hatcheries. The costs of installing and supplying oxygen would vary depending on the operational scenario, and this cost would be greatest if oxygen were used continuously. Capital costs for oxygen in this scenario are estimated at $100,000 per 30,000 pounds of fish or $33.3 million for 10 million pounds of fish. (Personal communication from Dr. Richard Speece, Drexel University, Philadelphia, PA.)

IV. Objectives in Improved Propagation

The objectives listed in Table 2 are in support of Section 704(h) and the goal of producing 2 million more adult salmon and steelhead per year. These objectives were derived from several sources. Specifically, BPA has consulted with the managers of fish culture in fishery agencies and their support staffs of pathologists, nutritionists, and researchers. BPA alos reviewed a 704(h) plan provided by the Columbia River Basin Fish and Wildlife Council, the work of the ad hoc Fish Health Protection Committee, the report of a BPA workshop on smoltification, and the final report of Bjornn and McIntyre (1985). BPA has also received and is evaluating the Council's issue papers on Salmon and Steelhead Planning, Genetics, Research, and the planning model.

The resulting objectives in this plan seek to accomplish the overall goal of improved propagation at existing facilities through increased rearing volume, increased rearing density, and increased fish health monitoring. This will also require human motivation and training in the new or related technologies. Evaluation and monitoring will be done to measure progress, both in terms of the plan and contribution to the fishery. Other objectives are included as supportive of these primary objectives.

Several simple, pragamatic assumptions were adopted to guide the development of this plan. The first assumption is that the required technology already exists to increase production at existing hatcheries by 2 million additional adults. This technology has been used in the Columbia River Basin for commercial aquaculture, but has not been adopted by fishery agencies. This also assumes that most hatcheries and their staffs already function reasonably well, but would be even more productive given the resources to do so.

<u>The second assumption</u> is that no panaceas loom over the horizon to revolutionize anadt-omous fish culture, nor is it justified to wait for one. This is because salmon and steelhead culture has been studied and practiced over 100 years, and most of the easy accomplishments have been made. Major new discoveries will be neither swift nor sure.

<u>The third assumption</u> is that the operating efficiency of a hatchery must be known to identify its problems, progress and future needs, as well as reward those responsible for its progress. This assumes that a Basin-wide hatchery evaluation program can be implemented, would be economically acceptable when costs are shared, and would have statistical validity and usefulness when completed. <u>The fourth assumption</u> is that human talents and motivation are a critical element in the formula for improving hatchery effectiveness. That is, hatcheries may house fish, but people rear them. It follows that education should be an ongoing process for hatchery staffs as well as for other professionals, and that peer review with incentive awards can be just as important as the investments in concrete and steel.

Table 2

List of Objectives for Improving Propagation at Existing Anadromous Fish Hatcheries in the Columbia River Basin
(not necessarily in priority order)

Objective 1. Renovate, expand, and modernize existing hatcheries to achieve full production potential.

Objective 2. Establish operational standards and evaluate all hatcheries for production goals, contribution, and practices in husbandry, genetics, and fish health.

Objective 3. Maximize hatchery staff talents and technology transfer.

Objective 4. Register biologicals, drugs, and chemicals for controlling diseases, parasites, and predators.

Objective 5. Plan ways and means of artificial production to meet BPA mitigation responsibilities.

Objective 6. Monitor and report fish health and related hatchery parameters.

Objective 7. Supplement natural production with hatchery outplants.

Objective 8. Fund research and demonstration projects to resolve identified problems in artificial propagation.

Subobjective 8.1 Improve strategies for rearing and releasing hatchery fish and improve husbandry and bioengineering practices.

Subobjective 8.2 Develop better ways and means to protect fish health from infectious and noninfectious diseases.

Subobjective 8.3 Assure genetic integrity in artificial propagation.

Subobjective 8.4 Promote better smoltification and early marine survival.

Subobjective 8.5 Identify why some hatcheries make extremely poor contributions to the fishery or to escapement and resolve the problem(s).

Objective 1. Renovate and expand existing hatcheries to achieve full production potential.

Rationale: Artificial production not only works, but it also sustains the bulk of the present run of anadromous salmonids in the Columbia River. Currently, there are about 54 regular anadromous fish hatcheries and 40 satellite facilities in the Basin. Additional water is available at a few facilities and these could be expanded quite readily. The expansion of underdeveloped facilities is proposed because it will produce adult fish more quickly, easily, and cheaply than new site development. Expansion typically requires neither the purchase of land nor the development of roads and utilities. Concurrent renovation and production may be possible.

GAIA (1985) lists 22 hatcheries in the Columbia Basin (Table 3) which might be expanded to reach full production potential. Total costs for remodeling in 1985 dollars is estimated to be $21.7 million which would increase production by about 1.7 million pounds of smolts, yielding an estimated 300,000 adults annually. By comparison, the estimated gross cost for new hatchery construction to rear 1.7 million pounds of smolts is about $70 million at $41.11 per pound of design capacity, and $119 million at $70 per pound of design capacity.

Yost of the hatcheries listed in Table 3 are below Bonneville Dam, and would not directly benefit upriver areas unless the production is reprogrammed and released in appropriate locations. Fish for upriver areas could also be produced via Objectives 5 and 7.

In addition to expanding the rearing space, moderately higher rearing densities are proposed at most of the existing hatcheries for at least part of the year. Salmon, trout, and steelhead are typically reared at a loading density under 0.8 lbs./ft.^{3}; as a general rule, Piper et al. (1982) recommends that loading densities (in pounds) be no greater than half their length (in inches) per cubic foot. This plan would approximately double the eventual load to about 1.6 lbs./ft.^{3}. Loading densities are limited in theory by the supply of oxygen, until ammonia becomes limiting (Speece 1981), although in reality, safe loading densities are also influenced by pathogens, and other environmental parameters (Piper et al., 1382). Thus, oxygen supplementation to allow increased loading density would require careful implementation and some testing for site specific considerations, as well as some training.

The use of supplemental oxygen is common in Europe (Speece, 1986). In the United States, this has been used widely to transport fish. In Oregon, supplemental oxygen has been

TABLE 3

Hatcheries with potential for increased production
and estimated costs (GAIA NORTHWEST, 1985)

Location	Potential Increase in Smolt Production (at 0.8 lbs./ft. 3)	Estimated Capital Costs	Required Feed (Lbs.)	Additional FTE Staff
Beaver Creek	16,000	$ 330,000	2,400	0.5
Bonneville	250,000	2,550,000	375,000	3.0
Clackamas	170,000	3,500,000	255,000	3.0
Cowlitz Trout	60,000	320,000	90,000	0.5
Kalama Falls	100,000	955,000	150,000	1.5
Leaburg	163,000	865,000	244,500	2.0
Lewis River	168,000	1,152,500	252,500	3.0
Lower Kalama	70,000	542,500	105,000	1.0
Marion Forks	25,600	425,000	38,400	0.5
McKenzie	140,000	1,905,000	210,000	1.5
Skamania	47,400	620,000	71,000	0.5
South Santiam	40,000	740,000	60,000	0.5
Stayton Pond	27,000	?	40,200	0.5
Speelyai	12,000	50,000	18,000	0.5
Vancouver	60,000	1,120,000	90,000	1.0
Willamette	90,000	1,037,000	135,000	1.0
Dexter Pond	20,000	N/A	30,000	0.5
Carson	96,000	1,810,000	144,000	1.0
Goldendale	27,300	3,500,000	41,000	0.5
Priest Rapids	40,000	150,000	60,000	0.5
Red River	24,000	N/A	36,000	0.5
Ringold Springs	40,000	120,000	60,000	0.5
TOTALS	1,686,300	$21,691,000	2,214,000	22.5

used successfully to commercially rear coho salmon and spring chinook salmon (personal communication Mr. Richard Severson, Oregon Aqua Foods, Inc.; and Dr. Ronald Cowan, Anadromous, Inc.). Michigan is using supplemental oxygen to rear salmonids including Pacific salmon, lake trout, lake whitefish, and steelhead trout. In most of these cases, loading densities approach 2 $lbs./ft.^3$, which is much higher than that proposed in this plan.

Supplemental oxygen can be required in at least three circumstances: (1) on demand when feeding increases oxygen consumption; (2) continuously all year because raceways are always loaded to high levels; and (3) continuous only after growth of fish results in rearing densities above prescribed limits, usually in the spring. Each scenario has quite different implications, and this is also true for costs. Thus, the specific equipment and the associated capital and O&M costs depend on the operational scenario.

Oxvgen supplementation continuously over the year is the most expensive to install (estimate $100,000 per 30,000 lbs. of rearing capacity) because any risk of failure justifies redundancy, collateral support systems, and required housing (Speece, 1981, 1985; Boersen, 1985). Seasonal supplementation is much less complicated, cheaper, and yet highly reliable (personal communications;

Dr. Ronald Gowan, Anadromous Incorporated; Lars Winlborg, Hoor, Sweden). On this basis, the capital cost of oxygen supplementation to increase smolt production would be:

$$\frac{\$100{,}000}{30{,}000 \text{ lbs. of fish}} \times 10{,}000{,}000 \text{ lbs. of fish} = \$33.3 \text{ million.}$$

As indicated elsewhere, O&M costs will probably be offset by decreased food costs, but this point needs further study.

The dissolved oxygen requirements of salmonid fish have been studied extensively, both at Oregon State University (see Warren, Doudoroff, and Shumway, 1973; Doudoroff and Shumway, 1970) and elsewhere (Speece, 1981). Recent information on dissolved oxygen criteria were summarized **by** Chapman (1986). Except at relatively low temperatures, any considerable reduction of dissolved oxygen from air saturation levels results in some reduction of growth and food consumption. Thus, one result of high oxygen levels is an increase in food conversion efficiency which alone may balance the O&M costs of the oxygen system (personal communication, Dr. Harry Westers, Michigan DNR, Lansing, MI; and Dr. John Colt, Davis, CA).

Oxygen supplementation involves a "new technology" in which ammonia would replace low oxygen as the limiting water quality parameter. Oxygen toxicity in this circumstance would be nearly impossible and recent developments in technology have vastly simplified oxygen distribution and monitoring (Boersen, 1985). Some site specific experimentation and renovation will be necessary, as well as staff training in the new technologies. However, this plan provides considerable time for planning, gradual implementation, and measured accomplishment.

Other renovations are needed at most hatcheries before the goals of full production, fish health protection, and increased benefit/cost can be achieved. Some facilities are old and in poor condition to achieve full production of quality smolts. Most facilities lack the means to accurately assess loading density, in part because they lack the means to monitor flows or oxygen. Many facilities need pathogen-free water for rearing early life stages. Another growing concern focuses on the pathogen level in the hatchery effluent as noted by Klontz, et al. (1978). Better sanitation procedures may be needed within hatcheries and possibiy for their effluents.

Costs for health related renovations were estimated on a preliminary basis using an average of $0.75 million per facility times 90 facilities, or about $67 million. This assumes that the funds would be spent to improve the water supply, waste treatment, and various other health related actions. As proposed here, the money would be in addition to, and not in lieu of, authorized maintenance.

Approach: BPA would develop a technical guidance committee to identify and refine the opportunities and costs for improving and expanding fish production at existing facilities as outlined in the "Implementation Process." Renovations will be consistent with the best available technology and not in lieu of authorized maintenance activities. where the indicated best technology merits it, full-scale demonstration projects will be undertaken before full-scale application.

Estimated lo-year Total Cost: $33 million for oxygen supplementation; $67 million for health related renovations; and $75 million for rearing additional' smolts; or

$175 million (total) including capital costs, expense, and O&M.

Time of Completion: Activity could begin in 2 years. Full production would be reached in 10 years.

Expected Benefit: 1,500,OOO additional adults per year at full implementation.

Objective 2. Establish site-specific operational standards to evaluate all hatcheries for production goals, contribution, and practices in husbandry, genetics and fish health.

Rationale: The need to evaluate hatcheries is obvious and has been indicated by several entities, including the Northwest Power Planning Council's Fish and Wildlife Program section 704(f)(l). Two types of evaluations would be appropriate; one based on the survival and contribution of resulting smolts, and the other evaluation based on compliance with best available technology (BAT). The need for peer evaluation of compliance with BAT is based on the premise that a staff could do everything right and warrant an award, but the resulting year-class could do poorly due to other factors. Peer review requires the emplacement of relevant standards and evaluation criteria, as well as the emplacement of a respected peer review team. This includes the development of standards for "fish quality" which will be applied both during the rearing period and at the time of release. The frequency of peer evaluations may differ between projects and can be decided by the Council. The evaluation of fish survival is best evaluated on life-cycle basis. Such evaluations should include the regular and experimental propagation of anadromous fish, whether by natural/wild means or by artificial propagation and would be accomplished via coded wire tags, etc., similar to the study by Vreeland (1985).

Some hatcheries already have operational standards based on best available technology, but others do not. Such standards not only can guide daily operations, but also can provide a basis for evaluating problems or successes and rewarding excellence. An appropriate portion of the smolts from each fish hatchery, as well as other significant projects would be marked and tagged. By thi means, one can assess the extent of the survival and contribution of these hatcheries, hence evaluate the benefits against the costs. While a marking program is essential to the evaluation process and could protect wild fish, it will not be necessary to tag all the fish.

Approach: Site-specific operating standards must be established using local knowledge and an advisory panel which collectively can tailor the numerical values to each unique situation. Experts would be nominated by the Northwest Power Planning Council with BPA underwriting the costs of this effort. The panel would also establish schedules for conducting operational reviews at every hatchery and develop the evaluation criteria and process. Evaluation of fish hatchery contribution per year requires a tagging program and a database. Such a database will be coordinated with similar needs in Objective 6, regarding fish health parameters.

Estimated lo-year Total Cost: $5 million.

Time of Completion: 10 years.

Expected Benefits: Hatchery Practices at BPA funded hatcheries will be upgraded and assessed against standards. Hatchery production will be quantified and analyzed for benefit/cost, degree of improvement, needs, and utilization. Outstanding performance will be identified and rewarded.

Objective 3. **Maximize** hatchery staff talents and technology transfer.

Rationale: The public investment in hatcheries has been huge, but it has been spent **mostly** for concrete, steel, and fish food. Unfortunately, hatcheries don't raise fish, people do. Thus, to the extent that hatcheries are successful, it is largely attributable to their staffs. Therefore, human talents comprise one of the most valuable resources at a hatchery, and this professional knowledge must be maintained, expanded, and rewarded. The resulting benefits accrue to the fish, the fishery, the region, and to the employee.

Currently, relatively little money is dedicated to the continuing education process as well as comprehensive transfer of new technology between different agency staffs and other entities. If new technology is not transferred or not implemented, the public investment in research is not only wasted,,but also the potential gains in production are lost.

Human moviation is also a critical element in improving the quality and quantity of propagation at hatcheries. Such motivation is most likely to come from positive rewards, peer recognition of accomplishments, and direct involvement in the program. Such involvement and understanding could foster rapid implementation of new technology, rather than undermine its potential benefits. Investments in human motivation would be small in cost compare to the investment in feed and remedial measures, and might be comprised of monetary or other appropriate rewards.

@roach: BPA will meet with hatchery operating agencies to exposure the opportunities for promoting technology transfer, human development and motivation among the approximately 400 public aquaculture employees in the Basin. This effort will investigate the possibility of developing a "peer" based, professional certification program for fish culture personnel. Annual training and other technology transfer processes are proposed, including visitations to modern salmon rearing facilities, and meetings both foreign and domestic. Special talents are available from existing college extension services which could be used with video-taped classes. Monetary or other awards for professional excellence and recognition are essential elements.

Estimated lo-year Total Cost: $1.6 million

Time of Completion: 10 years.

Expected Benefits: Increased effectiveness in implementing best available technology, and higher hatchery productivity.

Objective 4. Register selected bioogicals drugs, and chemicals for controlling diseases and predators of salmon and steelhead.

Rationale: Certain chemicals can be powerful tools to assist the production, health, and survival of anadromous salmonids. These include both therapeutics and disinfectants against infectious diseases and parasites, as well as pesticides to control predators and competitors in certain waters under certain conditions. These chemicals could improve **smolt** survival and quality, as well as reduce production costs. Several chemicals have known value for these purposes and others have potential value, but none can be used unless it has been registered for these specific purposes and therefore, available in the market.

Approach: BPA will work with the Pacific Northwest Fish Health Protection Committee and other regional experts to identify appropriate chemicals for registration, their relative priority, and their potential economic impact to the Fish and Wildlife Program. Initially, BPA will emphasize registration of materials to control bacterial kidney disease (BKD). This disease causes significant mortality in spring chinook salmon populations throughout the Basin, especially in upriver stocks. Currently, erythromycin is effective against BKD,but it only suppresses rather than **eliminates** the pathogen; its value could be lost by the development of drug resistance in the pathogen.

The effort to register all materials will be in addition to the work of relevant agencies and will be coordinated with the Interregional Project (IR-4) of the U.S. Department of Agriculture, U.S. Food and Drug Administration, U.S. Environmental Protection Agency, and U.S. Fish and Wildlife Service. As presently conceived, one coordinator from the private sector with recent, demonstrated expertise in chemical/drug registration should prosecute the registration of a given compound.

Estimated lo-year Total Cost: $6 million.

Time of Completion: 8 years.

Expected Benefits: Registration for use on salmon and steelhead of an IHN vaccine and BKD vaccine; an agent for fungus control on eggs and adults; Squoxin for squawfish control; erythromycin for BKD control; oxolinic acid for control of furunculosis and other gram negative bacteria; chloramine T for bacterial gill disease; Iodophore for disinfection; and an approved, nonpersistant anesthetic.

Objective 5. <u>Plan for additional hatchery production to meet BPA;s mitigation responsibility</u>.

<u>Rationale</u>: The losses of salmon and steelhead attributed to hydroelectric impacts are such that they probably cannot be mitigated without additional artificial propagation. Therefore, the objective here will be to determine how much additional artificial propagation will be needed, and to carefully plan where and how it can be accomplished at the lowest cost. For example, additional traditional hatcheries may be needed above Bonneville Dam, but the use of other technologies must be considered. Low capital options may be necessary because most of the desirable sites for traditional hatcheries have been developed already. Also, the use of temporary facilities might be desirable because they could be dismantled when and if viable populations of naturally produced fish are reestablished.

<u>Approach</u>: BPA expects the Sorthwest Power Planning Council's Production Planning process to define production objectives for each species of salmon and steelhead where losses can be attributable to hydropower projects. BPA will appoint

representatives of the agencies, Tribes, and PUD's, to serve on a tioengineering workgrou to determine the most appropriate options, develop schedules and estimate costs. The initial approach would be to sponsor a fisheries/bioengineering symposium in 1988 and use the attendees to identify the newest and best alternatives. Another critical step will be to review the production plan of each Subbasin Plan, the U.S. versus Oregon, and U.S./Canada settlements to identify the production profile of each resulting facility and where it will be used.

Estimated lo-year Total Cost: $0.6 million.

Time of Completion: 2 years.

Expected Benefits: The locations and size of all additional fish hatcheries will be identified, along with fish stocks to be reared. Production scenarios and conceptual designs will be completed.

Objective 6. Monitor and report fish health and related parameters.

Rationale: Early detection, prevention, and treatment of disease is a basic principle in fish health as well as in human health. Higher health status can minimize aquaculture costs and post-release losses of smolts to predators, turbines, transportation stress, infectious diseases, and an array of physiological dysfunctions. In this context, the term "health" includes concern for both infectious and noninfectious processes. Noninfectious disease agents include environmental parameters such as low oxygen, temperature, and ammonia; these can kill, but are usually more important as stresses which predispose susceptibility to infectious diseases. Careful monitoring of fish health therefore includes monitoring of pathogens and life support parameters, and this must be done regularly at all fish propagation facilities.

The full benefit of fish health monitoring cannot be achieved without the preservation and epidemiological analysis of the resulting data. This will require a database system whose content can incorporate tagging data from Objective 2, and would provide regular public reports and analyses. Since other hatchery parameters relate to or may impact fish health, one should combine as many relevant parameters in the database as would be cost effective both for historical records and evaluation purposes.

Approach: BPA has begun implementation of this objective with the fish hatchery operating agencies. State-of-the-art health monitoring has been defined and this has generally exceeded existing practices. Consistency across the Basin is being emphasized. Expansion of existing pathology staffs will bui ld uon an already cooperative and productive reiationship within hatchery operating agencies. The database **system** will include public access, and must be compatible across the Basin. Index hatcheries would be selected for in-depth evaluations of fish health.

Estimated lo-year Total Cost: $5.0 million.

Time of Completion: **5** years; at completion, hatchery operating agencies may continue with their own funding.

Expected Benefits: Aside from the database function, which alone has merit, the main benefit will be an estimated 25 percent increase in the success of **smolts** reared at hatcheries. This will produce an estimated additional 500,000 adults/year and also help protect wild fish.

Objective 7. Supplement natural production with hatchery outplants.

Rationale: Many streams contain marginal salmonid habitat which could be used to rear Pacific salmon and steelhead. In **some** cases these streams are underseeded and in other cases the streams may not support life-stages from spawning through hatching. If genetically compatible stocks are used, surplus hatchery fish could be outplants at appropriate sizes to supplement natural production. Such a scenario requires the identification of those streams which would benefit from supplementation, the amount of supplementation required, the appropriate stock(s), age/size, and any ecological amendments needed to promote salmon and steelhead production.

Approach: BPA began implementation by completing a work plan for the supplementation in the Columbia River Basin. Since then the Council has proposed a Technical Workgroup for supplementation. BPA will work closely with and rely on the Council's Supplementation Technical Workgroup, to develop subsequent supplementation plans. Critical to this project area is the application of adaptive management techniques and appropriate evaluation. Equally important is the need to evaluate previous attempts to supplement natural production via hatchery fish, and determine why they usually failed.

Estimated LO-year Total Cost: $7 million.

Time to Complete: 10 years.

Expected Benefits: Currently surplus hatchery fish would be outplanted to produce an undetermined number of adult fish.

Objective8. Fund research and demonstration projects to resolve identified problems in artificial propagation.

Introduction. Some thrusts of the Program will require the development of new information or solutions, which in turn depends upon rigorous testing of innovative ideas. In other cases, a proposed solution is known, but merits full-scale testing prior to area-wide implementation. Both areas concern the resolution of an identified problem which is impeding the primary goal of increased hatchery production, but involve significantly different risks. Because research topics are subordinate to a primary management goal and are relatively temporary in duration, they are listed here as subobjectives. Each subobjective is discussed with its own rationale and approach.

Sub-objective 8.1 Improve strategies for rearing and releasing hatchery fish and improve husbandry and bioengineering practices..

Rationale: The most obvious and logical strategy for reducing costs and increasing adult runs is to increase the survival of resulting smolts. Here the concern is to fine-tune or improve the strategies for rearing and releasing hatchery smolts so as to increase production of adult fish. For example, should one use various growth acceleration practices to rear smolts? 'Gould offshore liberation merit the cost? Such strategies might increase total production and total contribution, but other strategies need to be Identified 2nd evaluated. For example, spring chinook can be accelerated to produce 0 age smolts. If this provides adequate benefits at one location, would it work in upriver areas? Would it decrease the losses to BKD?

Yost fish husbandry practices have been established through years of refinement, and probably achieve most of the available biological potential. However, as hatcheries change, new opportunities and questions arise such as: At what point does crowding create stress in salmon and steelhead? How can fish be reared without handling them? What is the most cost-effective way to supply oxygen? How can one provide a cost-effective means of preventing transmission of diseases? Can computer assisted programs decrease costs and increase benefits?

Approach: BPA will work closely with the managers of fish culture programs to identify the needs and priorities in this subobjective. BPA will invite and encourage the participation of Tribes, PUD's, universities, and the private sector in informal workshops. Once the needs have been described and prioritized, the best proposals will be ranked by a peer panel.

Estimated lo-year Total Cost: $2.5 million.

Time of Completion: Develop a 5-year plan by January 1988 and identify probable benefits.

Subobjective 8.2 Develop better ways and means to protect fish health from infectious and noninfectious diseases.

Rationale: Disease impacts on anadromous species are largely unmeasured, but preliminary results show serious threats to both wild and hatchery fish. In the river, diseased fish are probably eaten by predators, and this usually goes unnoticed except when disease mortality exceeds consumption by predators and scavengers. In the hatcheries, mortality is more obvious, and diseases comprise known impediments both to full propagation potential and to post-release survival. Currently, most of the diseases of Pacific salmon and steelhead are without remedies which are both legal and effective. These diseases and their treatment must be viewed as part of the cost of operating a hatchery, the same as in the poultry and cattle industries.

Hatchery operations are potentially capable of impacting wild fish by discharging infectious agents to receiving streams, by interbreeding of wild/hatchery fish, and by nutrient/chemical discharges. For example, IHN infections at hatcheries can result in staggering numbers of virus being discharged to the stream. Horizontal transmission (fish to water to fish) of this virus is likely to contribute to higher "carrier" frequency, if not direct mortality in wild population. Better diagnostic tools are needed to identify “carrier” states.

Approach: BPA will work closely with the Managers of fish health programs to identify the priorities in fish health research. BPA will invite and encourage the participation by representatives of Tribes, PUD's, Universities, and the private sector. BPA will encourage and support ad hoc committees to develop appropriate strategies or plans of attach for each major fish disease. The Pacific Northwest Fish Health Protection Committee and other specialists will assist this activity and the development of project descriptions, evaluate proposals, and review ongoing fish health projects.

Estimated lo-year Total Cost: $24 million.

Time of Completion: Continuing.

Subobjective 8.3 Assure genetic integrity in artificial propagation.

Rationale: The literature is replete with concern for genetic diversity because it provides the resiliency by which populations adapt and thrive. While many gene pools of salmon may be relatively plastic, long term artificial selection, or the inadvertent limitation of traits could have profound impacts on stocks of salmon and steelhead. Ways and means must be found to prevent this in hatcheries, or in extreme cases, ways to maintain genetic diversity in artificially propagated fish. Clearly, harvest management plays an important role in this problem, but an obvious target is the hatchery system.

Riggs (1986) recently reported his view of genetic opportunities in salmon and steelhead planning. While his report is valuable and serves to identify major considerations, it does not deal with or guide the mundane, logistical, and mechanical aspects of its implementation. In sum, further guidance is needed which would reduce principles to actual practice (how to do it), and this is needed both for hatchery and wild fish. Such guidance is particularly critical to projects which propose brookstock and other culling procedures. Likewise, the potential benefits of selective breeding and fry culling must not be allowed to become counter-productive or overlooked.

Approach: BPA will convene informal meetings to identify the needs and means by which this objective can be met. Pending development of appropriate project descriptions, BPA would develop a Request for a Proposal (RFP) to accomplish this objective.

Estimated lo-year Total Cost: $0.8 million.

Time of Completion: 4 years.

Subobjective 8.4 Promote better smoltification and early marine survival.

Rationale: The parr to smolt transformation is a critical change in the physiology of anadromous salmonids which allows the transition from a freshwater to a seawater existence, and promotes migration. Currently, it is difficult to identify when this process and environmental parameters have reached optimal for maximum survival, hence the best time to release hatchery smolts is often uncertain. Likewise, it is impossible to tell when ocean conditions have reached the optimum for smolt survival. This information could be as critical for avoiding predation as it may be for maximizing osmoregulatory functions, and has a large potential for increasing smolt survival to adults. Tagged fish from Objective 2 will greatly aid the identification of a smolt's origin after release. Diets and general health also impact smoltification, and their role will be defined via Objective 6.

Approach: BPA has already conducted a "Smolt Workshop" with widespread participation. Both project descriptions and priorities were developed, but need updating in the light of recent findings and current focus. Again, BPA will rely heavily upon the Managers of fish culture programs to recommend appropriate priorities and describe projects.

Estimated lo-year Total Cost: $2.5 million to be provided on a cost-sharing basis.

Time of Completion: 5 years.

Subobjective 8.5 Identify why certain hatcheries make extremely poor contributions to the fishery or to escapement, and resolve the problem(s).

Rationale: Adult return to the hatchery varies considerably between hatcheries ranging from over 10 per 1,000 smolts released to less than 1 per 1,000 smolts released (Vreeland, 1985). Environmental conditions and **some** husbandry practices also vary between locations. It is possible that some of these practices are more influential than others, and might account for **some** differences in survival. Alternatively, chemical and physical parameters **may** contribute to poor survival and might lend themselves to amelioration. considering the capital and O&M costs which have been spent at most hatcheries, it would be extremely prudent to either correct their poor contributions, or shut down these facilities. But first the causative factors must be identified.

Approach: BPA will convene work with peer evaluation panels and an ad hoc technical Workgroup to identify two highly successful and two very unsuccessful anadromous fish hatcheries. Given assurance of the cooperation by the hatchery owner/operator, BPA will work closely with appropriate experts to develop a workplan by which the two locations can be compared, causative factors identified, and problems remedied.

Estimated lo-year Total Cost:	$1.5 million.
Time of Completion:	6 years.

IV. Implementation Considerations

Preliminary Budget Projects for Improved Propagation

The proposed budget totals $231.5 million over a lo-year period. Implicit in this budget is the assumption that all parties will quickly adopt the general concepts in this general plan and refine them later. If a slower or different approach is taken, expenditures will change accordingly. Currently the plan s budget requests $175 million for capital, O&M, and expenses directly related to producing 2 million additional adult salmon and steelhead per year. This comprises about 75 percent of the total lo-year budget. For example, $33 million has been allocated to provide supplemental oxygen, plus $67 million for health related renovations, and $75 million was included to provide O&M for the resulting increased production.

About 2 percent of the budget would be spent both on evaluating hatcheries and on increased fish health monitoring. About 2.6 percent of the budget would be allocated to registering new medication/drugs, and 0.2 percent would be spent on planning for new hatcheries. Supplementation projects would use about 3 percent of the budget. Research would be allocated $31.3 million and comprises about 14 percent of the total budget.

Finally, $1.6 million would be dedicated to educational and informational projects aimed at increasing human effectiveness at the hatcheries. This is a relatively small amount which could critically influence the overall success of this plan.

Bonneville Power Administration Manpower

If the proposed plan is adopted, considerable additional work will be generated for everyone. Stretching the formula of Coutant and Cada (1985) and one (1) COTR per $1 million to $2 million/COTR, then BPA would still need additional FTE's and additional staff. Without adequate staff, the projects could not be funded, implemented or managed as proposed. Thus, inadequate manpower for BPA's roles (Fish and Wildlife and Procurement) would also constrain implementation by the agencies and Tribes. Ideally, additional manpower should be available about a year prior to the need, so that they can be trained appropriately.

Schedule for Increased Propagation

A minimum start-up period of 2-3 years is required before general implementation can begin. This is because funds have not been requested for this plan, and with few exceptions must await the next BPA rate setting process. The current budget process requires submission before February 1987, of all new noncapital expenses for Fiscal year 1989, and all new capital costs for Fiscal Year 1990. While some reshuffling of noncapital funds is possible any year, the available latitude is not great. Thus, even if the proposed plan is approved in the current process, most new projects would not begin until at least 1989 (noncapital) or 1990 (capital).

TABLE 4

Estimated Cost for Improving Propagation of Existing Hatcheries
to Produce 2 Million More Adult Salmon/Steelhead per Year

	Qbiectives	Duration (Years)	Estimated 10-year Cost (X1000) Capital	Expense	Total	Percentage of Total
1.	Renovate and expand hatcheries to achieve full production potential	10	$100,000	$ 75,000	$175.000	75.6
2.	Establish site-specific operational standards to evaluate all hatcheries for production goals, contribution, and practices	10	-0-	5,000	5,000	2.2
3.	Maximize hatchery staff talents and technology transfer	10	-0-	1.600	1,600	0.7
4.	Register selected chemicals for controlling diseases and predators of salmon and steel head	6	-0-	6,000	6.000	2.6
5.	Plan for additional hatchery production to meet BPA's mitigation responsibility	2	-0-	600	600	0.2
6.	Monitor and report fish health and related parameters	5	-0-	5,000	5.000	2.2
7.0	Supplement natural production with hatchery outplanst	10	-0-	7.000	7,000	3.0
8.0	Fund research and Demonstration Projects					
8.1	"Improve strategies and practices	5	-0-	2,500	2,500	1.0
8.2	"Develop better ways to protect fish health"	10	-0-	24.000	24,000	10.4
8.3	"Assure genetic integrity	4	-0-	800	800	3.4
8.4	"Increase smoltification and early marine survival"	5	-0-	2,500	2,500	1.1
8.5	"Conduct operation research to identify..."	6	- -	1,500	1.5QQ	0.6
	GRAND TOTALS		$100,000	$131,500	$231.500	

GBouck:sc:5213:08/12/88 (VS6-PJSR-5733N)